

A new class of nonuniform, broadband, nonsymmetrical rectangular coaxial-to-microstrip directional couplers for high power applications

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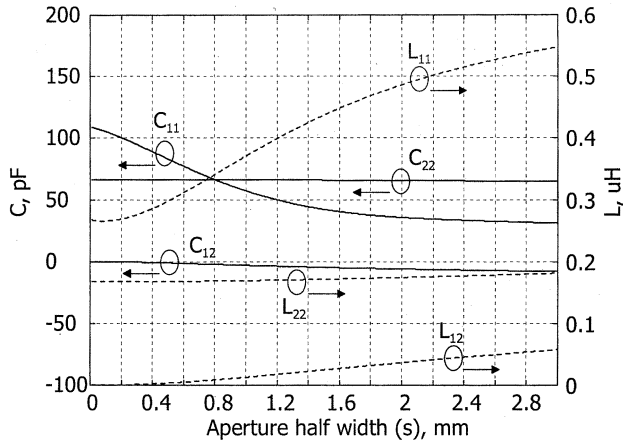


Fig. 2. Elements of the per unit length capacitance (continuous lines) and inductance (dashed lines) matrices, versus aperture half width s for the realized couplers (1: coupled line, 2: main line). Cross section dimensions (see Fig. 1) are $R = 3.5$ mm, $h = 15$ mm, $D = 20$ mm, $t = 70$ μ m, $S = 3.078$ mm, $H = 508$ μ m, and $w = 1.15$ mm.

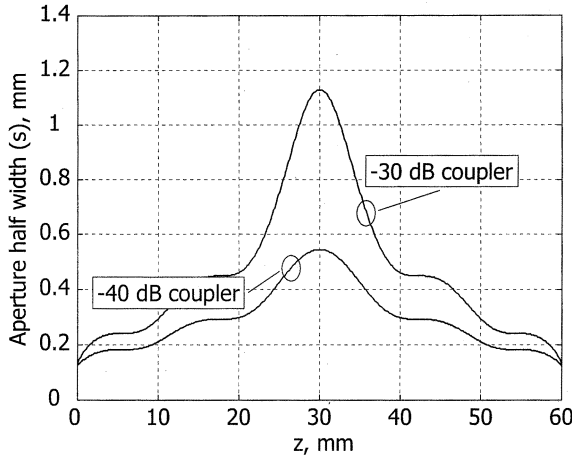


Fig. 3. Designed aperture half width s versus longitudinal direction z for the two realized couplers.

revised, implemented in MATLAB and applied to the novel coaxial-microstrip structures.

The set of broad-band couplers designed and realized with the proposed methodology is composed by a rectangular coaxial structure plus two different dielectric substrates, for coupling coefficients of respectively -30 and -40 dB in the band from 900 MHz to 5.5 GHz. The maximum coupling achievable with these novel structures is mainly limited by the realization technology and mechanical tolerances, determining the distance S . For the realized structure, the maximum coupling coefficient obtainable was of about -20 dB.

It would be possible to extend the band to lower frequencies, by increasing the coupler length, which has been chosen to be 60 mm. The limitation to the upper frequency instead is mainly imposed by the substrate material losses.

The resulting aperture variation versus z , $s(z)$, is shown in Fig. 3 for the two couplers. Schemes of the realized substrate bottoms are shown in Fig. 4. Apart from the aperture width s , which varies along z , the designed structure has the following transversal dimensions (refer to Fig. 1): $R = 3.5$ mm, $h = 15$ mm, $D = 20$ mm, $t = 70$ μ m, $S = 3.078$ mm, $H = 508$ μ m,

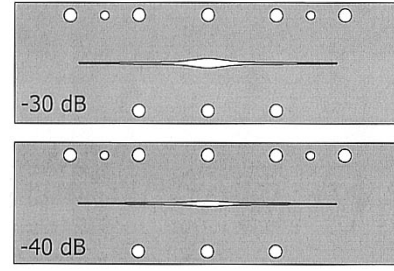
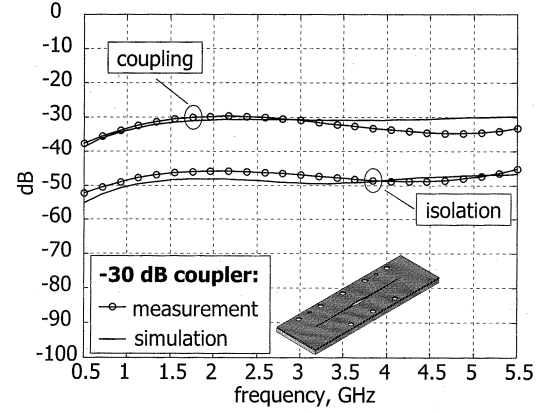
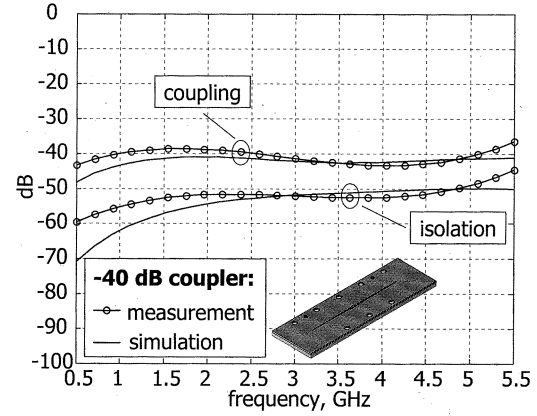


Fig. 4. Schemes of the substrate bottoms for the two realized couplers.



(a)



(b)

Fig. 5. Measurements and simulations of $\mathcal{K}(f)$ and $\mathcal{I}(f)$, coupling and isolation coefficients versus frequency, for the realized directional couplers: (a) -30 dB coupler (b) -40 dB coupler. Measurements are highlighted with circles.

and $w = 1.15$ mm. These dimensions were chosen in order to grant that both the main line and the microstrip have 50 Ω characteristic impedances when the aperture width is reduced to zero to facilitate impedance matching at the connector interfaces. The choice of $R = 3.5$ mm allows the main coaxial line to be interfaced with the 7/16 series of coaxial high power connectors limiting mismatching losses. The substrate for the microstrip has 508 μ m height, with dielectric constant $\epsilon_r = 3.2$ and copper thickness of 70 μ m.

Finally, 4-ports scattering parameters measurements of the couplers have been performed with a three port Vector Network Analyzer. In Fig. 5, the calibrated measurements and the simulation results are shown. The measured coupling coefficient $\mathcal{K}(f)$

(circles) for the two different couplers shows good agreement with the expected coupling. The measured coupler directivity is more than 10 dB over the whole band, thus comparable to many stripline commercial couplers (10–15 dB). The measured return loss (S_{11}) and insertion loss (S_{21}) over the bandwidth of 0.5 to 5.5 GHz is greater than 17 dB and less than -0.4 dB, respectively.

The maximum power injectable before the dielectric breakdown occurs has been computed. FEM field simulation have been performed as function of the aperture width for the realized structure. By assuming dry air dielectric breakdown field of 3000 kV/m and under matching conditions, the maximum bearable power is of about 30 kW.

III. CONCLUSION

A new set of coaxial-to-microstrip coupling structures has been proposed and analyzed, in order to overcome the main drawbacks of coaxial, waveguide, and stripline couplers. These structures represent a great improvement for high power measurement systems, since they have broad-bands, good directivity, and can be easily designed and fabricated.

A set of broad-band coupler prototypes has been constructed and measured, showing good agreement with the simulations, confirming the validity of the proposed design methodology and

demonstrating the attractive characteristics of this new design approach.

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